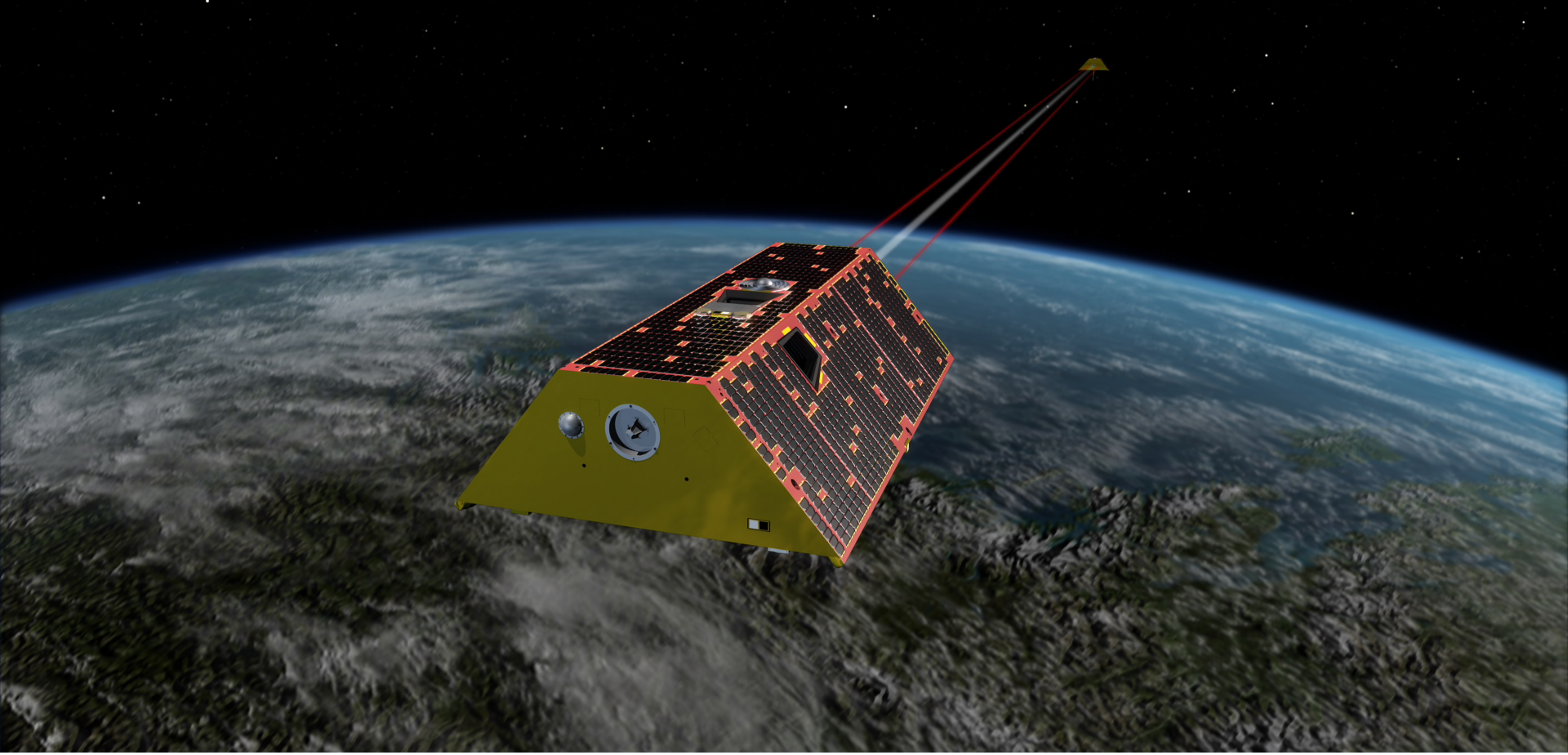


GRACE Follow-On

Laser Ranging Interferometer

AGU Fall Meeting 2019

Samuel P. Francis for the US and German LRI collaboration

Jet Propulsion Laboratory
California Institute of Technology

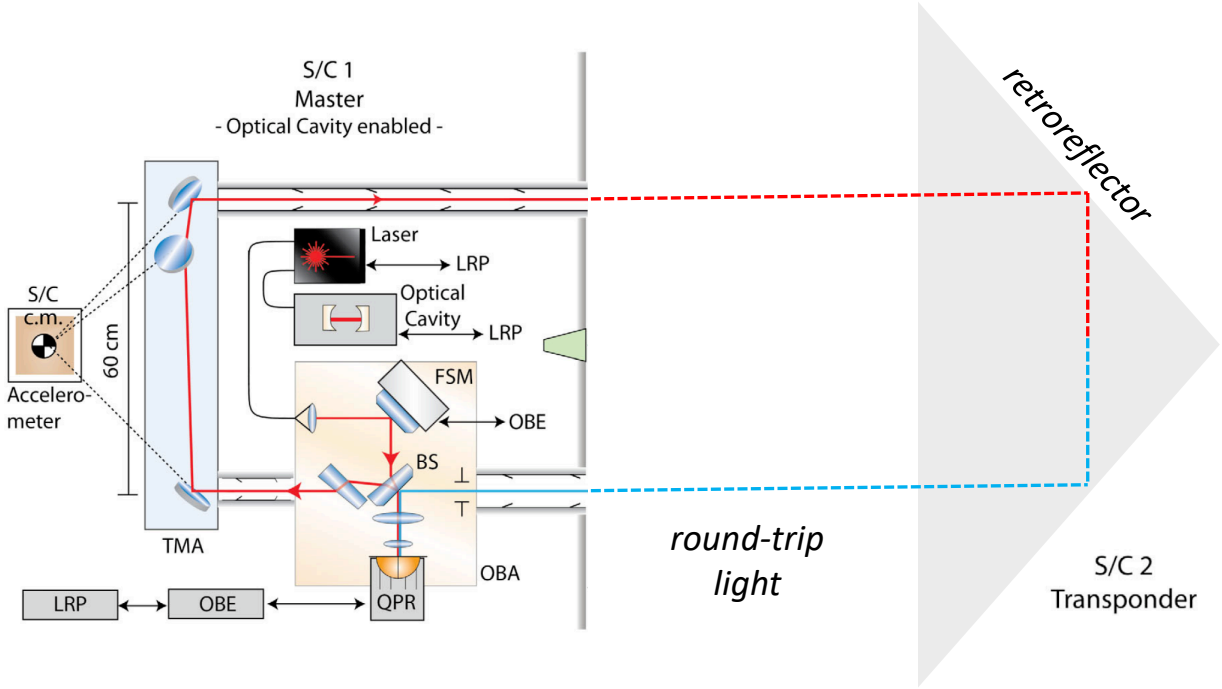
Laser Ranging Interferometer Team

Adlershof
Bremen
GSOC

Overview

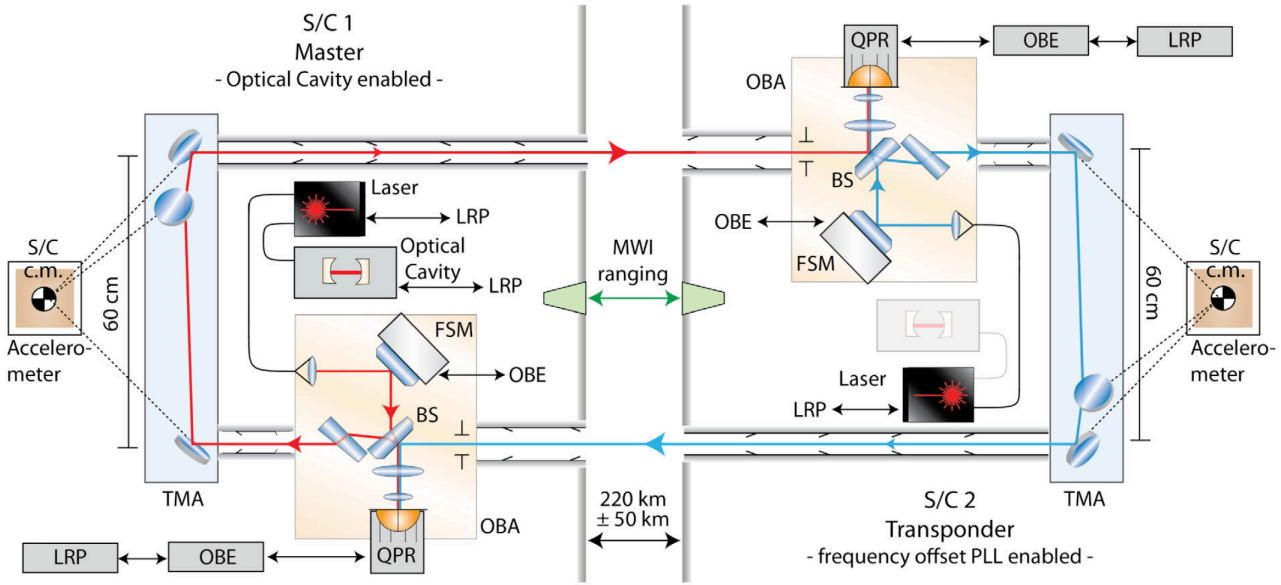
- Laser Ranging Interferometer Instrument
- In-orbit performance:
  - Phase jumps
  - Coupling of attitude control thrusts into along track
- Summary

Laser displacement measurement concept



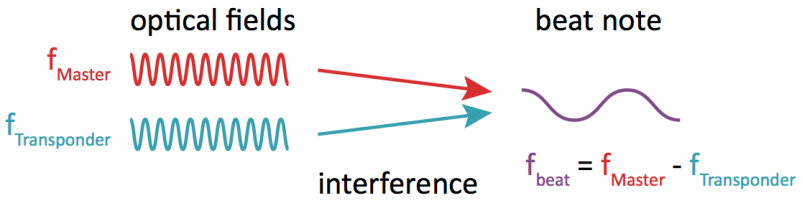
To measure change in separation between satellites we ideally would compare local laser to a laser that has traveled round-trip

Laser Ranging Interferometer (LRI)



Master: *where measurement is made*
Transponder: *"Reflects" light back to master*

Gravity signal is a millihertz phase modulation of the megahertz beat note between the two optical fields



LRI is performing well

First inter-spacecraft laser interferometer

Maintained science link for over 1600 orbits (100 days)

When it was lost, reacquired link within 25 seconds

Absolute laser frequency variations on order 40 MHz between Dec '18 to Aug '19

Center of mass maneuvers show tilt-to-length coupling is not limiting performance

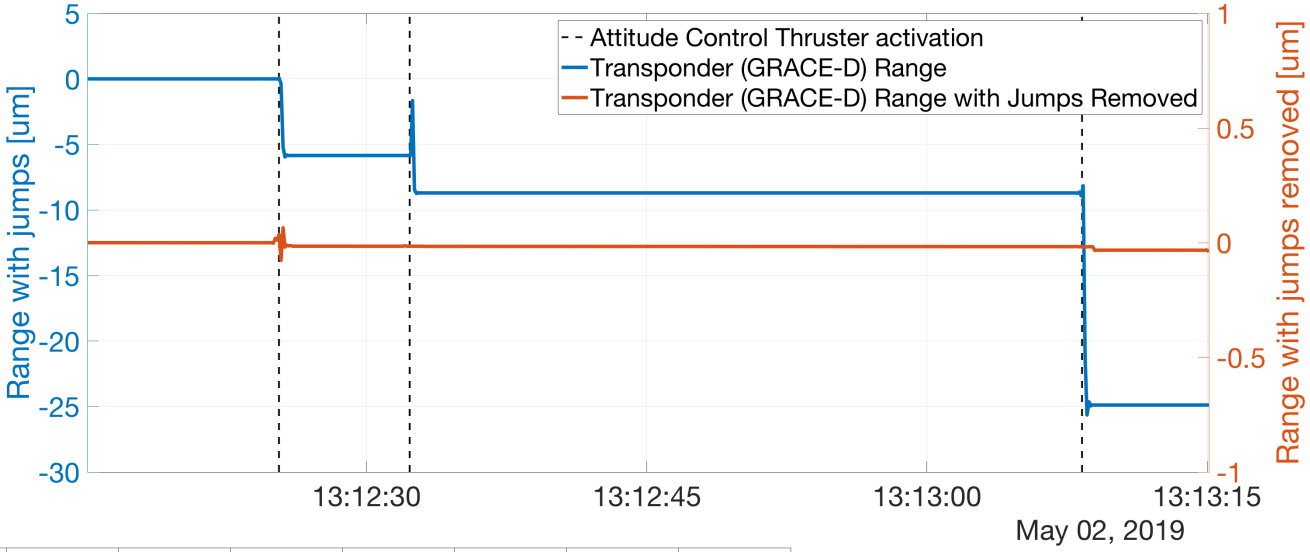
LRI and KBR separation measurements agree

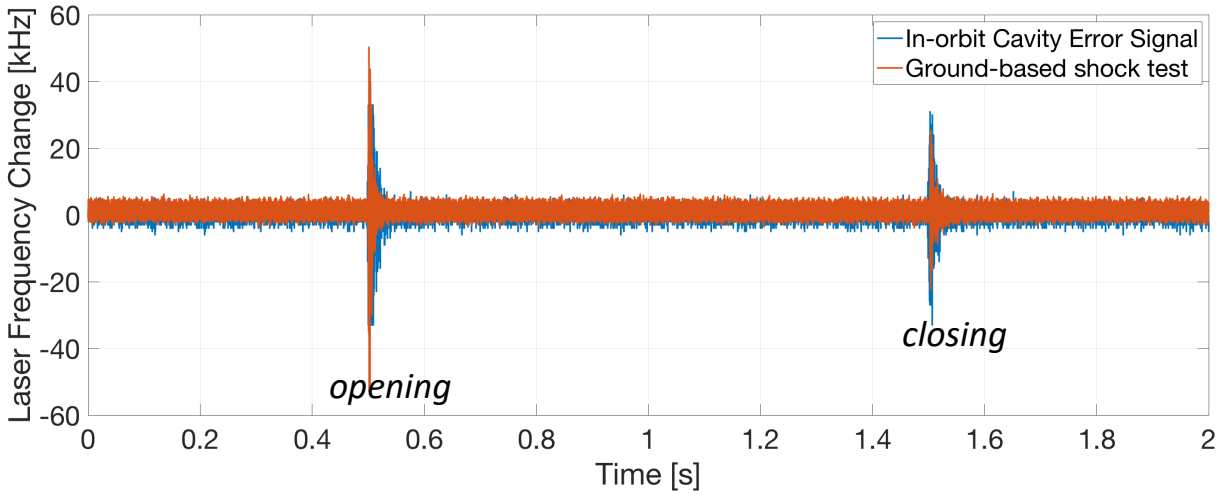
More on the in-orbit performance: PhysRevLett.123.031101

Phase jumps coincident with thruster opening/closings

Phase jumps appear in both master and transponder

Caused by fast laser frequency changes from thruster opening/closing shock





Ground tests confirm phase jumps are due to mechanical shock and not EMI

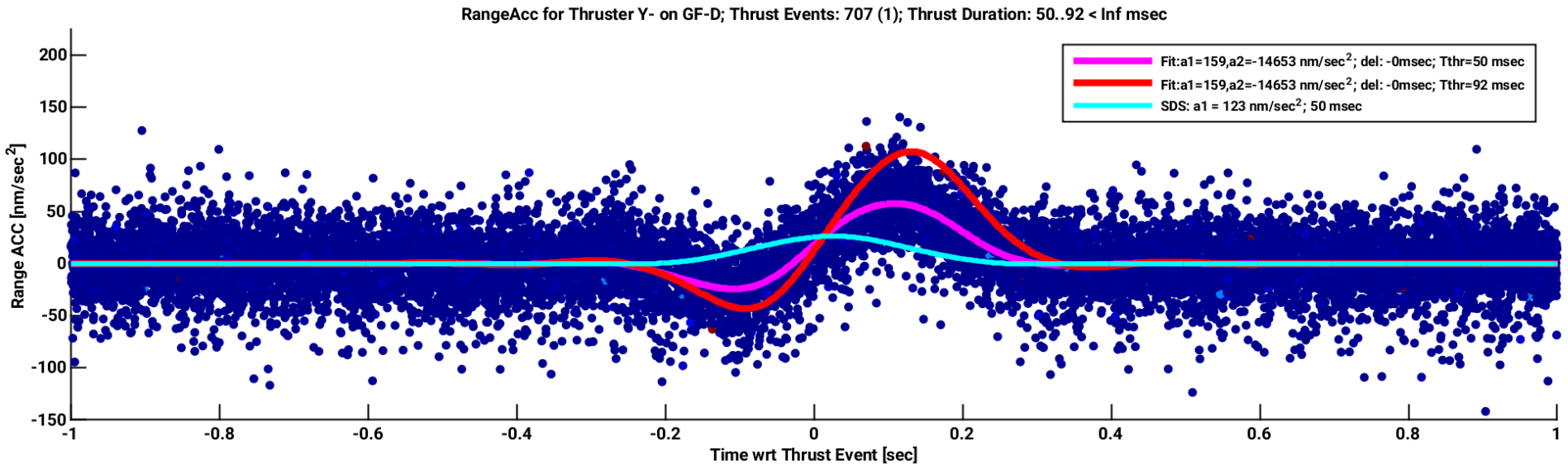
Phase jumps can be subtracted from range data by fitting the known step response of onboard filter (implemented in L1B)

Coupling of attitude control thrusts into along track

LRI team members at AEI Hannover – Vitali Müller, Malte Misfeldt, Henry Wegener, Gerhard Heinzel – discovered that satellite accelerations from thrusts appear in LRI range measurement

Not the same as phase jumps:

Phase jumps are caused by thruster valve opening/closing. This is acceleration of satellite from imbalance in attitude control thrusts.



Sensitivity to thruster accelerations in along track means it is possible to calibrate thruster profiles using LRI range

Summary of LRI status

- The first inter-spacecraft laser interferometer, the GRACE Follow-On Laser Ranging Interferometer (LRI), has been successfully operating since June 2018

- The LRI range is sensitive to micro-shocks from the attitude control thrusters, and small along-track accelerations from the thrusters.

- LRI is performing well: in frequencies above the gravity signal roll-off ($f > 30$ mHz) the sensitivity is laser frequency noise limited once these have been taken into account

- Sensitivity below 30 mHz is ongoing work